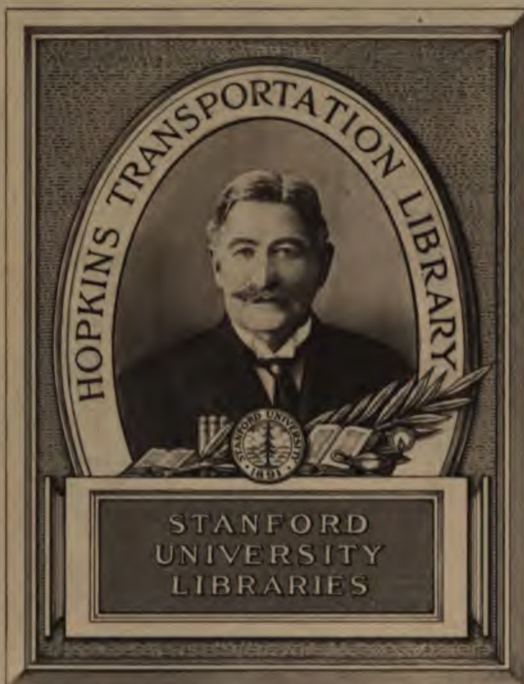
D. L. Harris
Hoosac tunnel.



THE

HOOSAC TUNNEL

AND

Troy and Greenfield Rail Road.

1862.

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1862.

Commonwealth of Massachusetts.

State House, Senate Chamber,
Boston, February 17th, 1862.

Dear Sir: The undersigned is instructed by the Committee on so much of the Governor's Address as relates to the Troy and Greenfield Rail Road, to obtain the information sought in the House Order of February 1st, concerning that matter; and he will be obliged if you will, at your earliest convenience, furnish answers to the inquiries contained in the enclosed paper.

Yours, Respectfully,

JOHN J. BABSON.

D. L. Harris, Esq.

Whether the actual cost of the portions of the Tunnel already done has been greater or less than the original estimates, and how much greater or less?

What it will cost to finish the work, and the time it will require to do it?

Also, how much it will cost to complete, and put in running order the other portions of the Troy and Greenfield Rail Road?

HOOSAC TUNNEL

AND

TROY AND GREENFIELD RAIL ROAD.

SPRINGFIELD, March 8, 1862.

Hon. JOHN J. BABSON, of the Committee on Troy and Greenfield Railroad, Massachusetts Legislature.

SIR :—Your communication covering certain inquiries relative to the Hoosac Tunnel and the Troy and Greenfield Railroad, was duly received. In complying with its requests, I will take up the questions in the order they are presented.

1*st*. *Whether the actual cost of the portions of the Tunnel already done has been greater or less than the original estimates, and how much greater or less.*

The original estimates for the Hoosac Tunnel, made by the engineer of the Troy and Greenfield Railroad Company, and reported to the Legislature in 1848, (Senate Document No. 120,) and subsequently in 1853, (House Document No. 125,) were as follows :—

ESTIMATE.

"The length of Tunnel, from heading to heading, is 24,100 lineal feet. In volume, equal to 15 cubic yards per lineal foot. Total amount of excavation, 361,500 cubic yards. Cost of Tunnel per lineal foot, $69.52, viz.:—

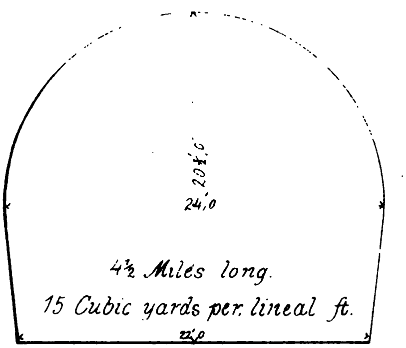
A, 36 feet, at 50 cents per foot, $13 50 a yard,	$18 00
BB, 100 " 30 " " 8 10 "	30 00
C, 269 " 8 " " 2 16 "	21 52
405 cubic feet, equal to 15 cubic yards,	$69 52
Cost per cubic yard,	$4 63½

The whole amount for excavating Tunnel,	$1,675,432 00
Masonry, 6,025 perches, at $5,	30,125 00
Air pipes. 1,085 tuns, at $50,	54,000 00
Superstructure, including iron, &c.,	64,000 00
Engineering and contingencies,	125,000 00
	$1,948,557 00"

This estimate, which, exclusive of superstructure, amounts to about $78 per lineal foot, contemplated the construction of a tunnel for two tracks; the same to be arched wherever necessary, and completed in all respects ready for use. The proposed dimensions, as elsewhere stated by the engineer, were to be 22 feet wide at bottom, 24 feet wide at the spring of a semi-circular arch forming the crown or roof, and 20½ feet high. So far as can now be judged, the prices for the work were liberal, on the assumption that no unforeseen difficulties would be encountered. Very small allowance appears to have been made for contingencies, though the engineer states that these are intended to be covered in the "prices per yard, which are very much increased from what they truly ought to be," in order "to cover every expenditure and contingency."

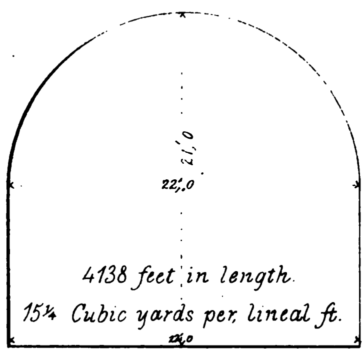
The question whether the actual cost of the portions of tunnel already done, has been greater or less than the above estimate, is embarrassed by the circumstance that no part of the work has been done according to the plan therein contemplated. The original loan act of 1854 provided that the tunnel might be built "of size sufficient for one or more railroad tracks," and in July, 1856, the railroad company made a contract, which, while it provided that "the great tunnel and its approaches shall be estimated at two millions of dollars for a double track," at the same time stipulated that "the contractors might build the tunnel for a single track; in which case, no abatement in price shall be made for the first three thousand feet, but afterwards the sum of twelve dollars per lineal foot shall be deducted for the remainder." It was also stipulated that "the hight of the tunnel shall not be less in centre than 18 feet above rails," and "not less than 14 feet wide." It appears, however, from the statement of the engineer sent by the Governor and Council to examine the work, that when, in October 1859, the first advance of scrip was made on account

Cross Sections of Tunnels.

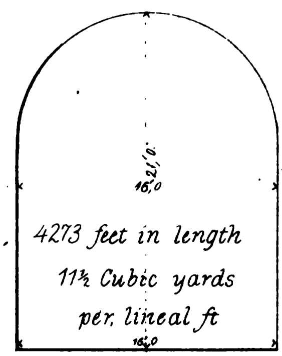


Hoosac Tunnel as projected and estimated upon when loan was originally granted.

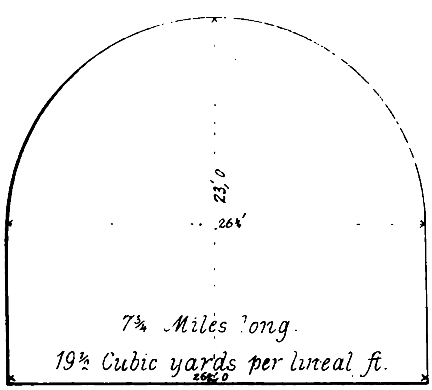
Hoosac Tunnel as thus far completed.



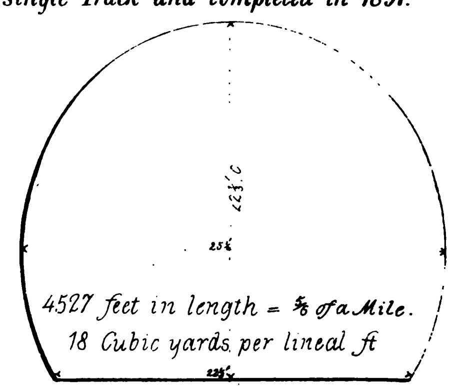
Kingwood Tunnel, Baltimore & Ohio R.R.



Blue Ridge Tunnel in Va. constructed for single Track and completed in 1857.



Mont Cenis Tunnel Under the Alps.



Tunnel at St. Martin's, on Bourbounais R.R. France.

Lith. by K. Bradley Springfield Mass.

of the tunnel, the average size of the gallery at the east end, was only 13½ feet wide by 14½ feet above the rail.

In the modification of the loan act, made in 1859, it was formally provided by the Legislature, that the tunnel might be excavated 14 feet wide, with a total hight of 18 feet. A tunnel of this latter size contains 8½ cubic yards in each lineal foot, against 15 yards per lineal foot in the structure upon which the original estimates were based. In order to arrive at a better understanding of these dimensions, and to aid your Committee in judging of their sufficiency, I present cross-sections of the original and present plan of the Hoosac Tunnel, with sections of sundry other important tunnels recently completed or now in process of construction. (*See Plate.*)

With a liberal allowance for contingencies, the cost of excavating the gallery 2,300 feet long, 14 feet wide by 18 feet high, on the east side of the Hoosac Mountain, has probably fallen short of $35 per lineal foot; it certainly has not exceeded $40 per lineal foot—*say* $37½ *dollars*, being less than one-half the original estimate for a double track tunnel. On the west side of the mountain, for half a mile from its base, the line of the tunnel is through a secondary formation differing entirely from the material of the mountain proper. Of this distance the first five or six hundred feet, now excavated, is through loose limestone, abounding in water, and exceedingly difficult to remove. This part of the work should have been built as an open cutting, the depth of rock and earth over the top of the gallery being too small to have warranted that kind of structure. If completed as a tunnel it will require substantial arching and side-walls, which have not been provided; the superincumbent materials being now supported on posts, timbers and planking, which are fast going to decay. The cost thus far has probably amounted to $100 per lineal foot for the excavation and propping up. The necessary arching may be estimated at $40 a lineal foot additional. So far, therefore, as a comparison can be made between "the actual cost of the portions of the tunnel already done," and the "original estimates," the accounts will stand as follows, viz :

ORIGINAL ESTIMATE.

2,300 feet of gallery excavated at east end.
550 feet of " " west end.

Total, 2,850 feet, at the average of original estimate for double track tunnel, $78, would amount to	$222,300 00

COST OF WORK DONE.

Excavating 2,300 lineal feet at the east end for a single track, 14 feet by 18 feet, at $37½ per foot,	$86,250 00	
Excavating and propping up 550 feet of gallery at the west end, at $100 per foot,	55,000 00	
add Probable expense of arching same, 550 feet at $40 a foot,	22,000 00	163,250 00
Difference,		$59,050 00

2d. What will it cost to finish the tunnel, and what time will be required to do it?

This question will be considered in two parts—as to *cost* and *time*. *First*, as to cost. It should be observed that everything depends on the internal structure of the mountain. The material at the inner end of the eastern gallery, and the shaft near the western base of the mountain, is of the same character. It consists of a soft micaceous or talcose slate, imperfectly stratified, and containing numerous lumps and nodules of quartz rock (flint). The layers stand on edge, and are said to be slightly inclined toward the mountain; that is, on the east side the inclination is to the west, and on the west side toward the east. If it could be known that the material is of this same character, and that the relative position of the strata remains unchanged throughout the intervening three and a half miles from the eastern gallery to the shaft on the west side, the estimates of the cost would be easily arrived at. But all experience leads us to anticipate serious changes in such a distance. The mica slate, interspersed with quartz ~~and~~ nodules, may give place to beds of pure quartz, feldspar, serpentine, or some other description of rock found in this range of mountains. President Hitchcock, in his report of the geological survey of the state, tells us that the Hoosac Mountain region has been the theater of grand disturbing causes in the earth's history. I present a few extracts shadowing forth his opinions:—

"Berkshire County contains the principal repository of quartz rock. It is there interstratified with gneiss and mica slate, especially along the valleys of that county. * * * In Savoy it occurs near the top of Hoosac mountain.

"There are some facts that lead us to believe that there exists, in the western part of Massachusetts, extensive fractures or faults coincident in direction with the ranges of mountains. One of these is the existence of thermal springs at Williamstown, New Lebanon and Mount Washington. For, in most every other part of the world, such springs indicate fissures in the rock, reaching to a great depth. Another fact is dolomitization, which has taken place in this County, and which I shall soon describe more particularly.

"Such are some of the marks of the powerful action of internal heat upon the rocks of Berkshire County. To the geologist and chemist they are as striking and convincing almost, as the lava and smoke of Vesuvius are to the common observer."

These views of Professor Hitchcock certainly indicate the probability of changes being met with in the formation of the Hoosac mountain; but, should the rock continue to be mica slate, it may assume a less compact and adhesive character, or the position of the strata may be changed from vertical to horizontal. In either event the expense of a tunnel would be enhanced, and, should the structure of the rock be so far varied as to admit the percolation of water in large quantities, the cost would become *altogether problematical.*

If, however, we may be allowed to assume, for a basis of calculation, a simple gallery 14 feet wide by 18 feet high, under the mountain proper, three and one-half miles, and also assume that the material found at the east side, and at the shaft near the western base of the mountain, will remain unchanged in character and relative position throughout, it is safe to estimate the cost at $60 per lineal foot. Under the same conditions, the cost of a tunnel 23 feet wide by 20½ feet high for two tracks, as originally designed, would probably fall within $75 per lineal foot; but the difference between $60 and $75 per lineal foot must not be taken as an estimate of enlarging a tunnel of the smaller size after it has been brought into use. The cost of the latter operation would, in all probability, be not less than three times this difference. The above remarks apply to that part of the tunnel under the mountain. I come now to the half-mile beyond its western base.

As before stated, the gallery at the west end, some 550 feet long, was excavated through a body of loose limestone; beyond this point, the material changes to *earth* and *quicksand*, abounding in water, and in which very little progress has been made. The present indications are that this formation will continue, with little interruption, to the base of the mountain—say, 2,750 feet, or about half a mile. There can be no doubt that a tunnel through these materials will require heavy side walls, with substantial arching overhead and, through much of the distance, an inverted arch at the bottom.

The cost of this part of the work cannot be foretold with any tolerable approximation to accuracy; $250 and $400 per lineal foot may be named as the limits within which the actual cost would be likely to fall. For the purpose of arriving at an estimate, let us assume it to be $300 per lineal foot, for a single track tunnel, 14 x 18 feet. The cost of a tunnel for two tracks would be from 25 to 40 per cent. greater—say $400 per lineal foot. But if the smaller tunnel were to be first completed, and subsequently enlarged for two tracks after being brought into use, the cost of the second operation would be likely to equal the first. Even if the gallery should be first excavated for a single track, and temporarily sustained with timber, and afterwards, before the tunnel was brought into use, it should be determined to enlarge and arch it for two tracks, the total cost, resulting from such management, would be from 50 to 75 per cent. greater than the cost of accomplishing the same result at one operation.

In corroboration of these statements, I will refer to the tunnels on the Baltimore and Ohio Railroad. They were constructed mostly through mica slate rock, and were generally 16 or 17 feet wide, to accommodate a single track. After the road was opened through, say from 1854 to 1860, the expense of timbering, widening and arching fourteen tunnels, measuring in the aggregate 11,300 lineal feet, was $995,640, being an average of $88 per lineal foot.

The case of the Lindell tunnel in England is also in point. This tunnel was completed and put in operation in 1851, for a single track; three years later it was decided to enlarge it for a double line. The operation was accomplished for about $63

per lineal foot—more than double the cost of the original construction. "Before the works of enlargement were commenced, the contractor suggested that another single, or twin, tunnel, parallel with the existing one, could be constructed with less risk, and he offered to complete it for the same sum, notwithstanding the additional excavation necessary for the approaches. The proposition had not been favorably received, because there was no precedent for such a work, and because it was known that there were many and *grave disadvantages* in working a single line tunnel."

There is one other element of cost which must not be overlooked in a work of this magnitude and duration. I refer to interest on the amount expended as the work progresses. The average annual outlay for completing the Hoosac Tunnel, of the dimensions heretofore adopted, would probably be $108,000; the amount of interest on this sum, at five per cent., is $5,400; the interest account would, of course, be increased from year to year by this sum, (in addition to interest upon interest,) and, before the completion of the tunnel it would become nearly $145,000 per year. I find the total amount of interest on future expenditures, computed on this basis, to be about $1,100,000.

Bringing together the foregoing results, I present them as my estimate of "the cost to complete" a tunnel of the present limited size, on the supposition that the structure of the mountain proper will correspond throughout with its present character at either side, and no water be found.

ESTIMATE.

18,500 lineal feet, say three and one-half miles, of unarched Tunnel, for single track, under the Mountain, at $60 per foot, - -	$1,110,000 00
2,750 lineal feet, about half a mile, of arched Tunnel, for single track, on the west side, at $300,- - - - - -	825,000 00
Interest, at five per cent., on expenditures until completion,	1,100,000 00
Total, - - - - -	$3,035,000 00

Should it be determined to enlarge the dimensions and construct a tunnel in the first instance for two tracks, an additional sum, equal to thirty per cent., say $910,500, will be required.

My estimate has been made up on the basis of a tunnel 14 feet wide by 18 feet high, because the construction thus far

purports to be of that size, and that size was authorized by a former legislature. If there is to be any new legislation on the general subject, I suggest the propriety of inquiring whether there cannot be some improvement in this particular. That a tunnel four and one-half miles long, 14 x 18 feet in size, and rising to a summit in the middle, will answer for the passage of trains carrying passengers, is scarcely possible. Without the most thorough ventilation, the smoke and gases proceeding from the locomotives, combined with the exhalations from natural sources, will so vitiate the atmospheric air as to render it wholly unfit for respiration. That such ventilation, under circumstances as supposed, can be attained within the limits of any moderate expenditure, if at all, is exceedingly doubtful. The air in such places becomes dense and sluggish. While constructing the Blue Ridge tunnel, as I learn on the authority of the engineer, owing to the density of the air, smoke occasioned by blasting often times did not clear away sufficiently, between Saturday at midnight and Sunday evening, to admit the use of instruments by the engineers in testing the accuracy of the line. Although abundance of fresh air was driven in through tubes and discharged at the headings, it was found in practice to be so much lighter than the air, which was charged with noxious vapors, as to rise above it and escape along the roof of the tunnel.

A large and costly shaft over the apex of the grades, near the middle of the mountain, would certainly be indispensable, if the tunnel were of the size originally contemplated. Indeed, it is more than doubtful whether the tendency of the air to rise in such a shaft would be sufficient to set in motion the heavy vapors filling the tunnel, without the aid of a large fire in the shaft, or powerful fans to drive them along, retarded as they would be by friction against its outline. *I consider it certain*, that, even with a central shaft and powerful machinery to urge the dead air and gases along, it would be impossible to keep the atmosphere of the tunnel, if only 14 feet wide by 18 feet high, pure enough to make breathing tolerable.

The case is somewhat different at Mont Cenis, where shafts are impracticable. The area of that tunnel, as I have shown on a former page, is more than twice as great as the present

area of ours, its grades are differently arranged, and it is reasonably hoped that the powerful machines now employed to discharge compressed air at the headings, for driving the drills and for ventilating the tunnel while being constructed, will suffice to propel a moderate current through its whole length.

Second. As to the time in which the tunnel can be completed.

The progress in future must be calculated from what has already been accomplished on this work, and from what is known of the rate of advance in other tunnels. From a careful examination of the reports of the engineers employed by the State, I find that the progress at the east end of the Hoosac tunnel, between September 1st, 1858, about which time the first advances of State scrip were made, and October 1, 1859—a period of thirteen months—was, on the average, 39 lineal feet per month; from that time until April 1, 1860, the progress was 35 feet per month; and from the latter date till the suspension of operations, about July 1, 1861, the average monthly progress was 56 feet. As the work is known to have been continuously prosecuted during the latter period, under the administration of the present loan act, which authorizes the advance of $50 in State scrip for each lineal foot of tunnel—a sum exceeding by at least 25 per cent. the actual cost at present—it may be fairly concluded that 56 feet per month, or about two feet per day of 24 hours, is the highest attainable rate of progress at the eastern end.

At the great Mont Cenis tunnel, with all the advantages of skilled labor, and the economy of prosecuting the work from the open ends, the average rate of advance for some two years, while hand labor only was employed, was 16 inches per day, or 35 lineal feet per month, at each face.

The shaft at the western base of the mountain is the only other point from which, according to present plans, the balance of the tunnel under the mountain proper, for three and a half miles, is to be driven; consequently, the duration of the work is to be measured by the progress between the east end and this shaft. It is impossible to work so rapidly from the bottom of a shaft as from an open entrance. In proof of this, I refer to the experience gained in the construction of several noted tunnels, which, for the purpose of expediting the work,

were, to a great extent, driven by means of shafts. From data furnished by the engineer of the Black Rock Tunnel on the Reading Railroad, it appears that the average advance from the two ends was 40½ lineal feet per month, while from the shafts it averaged but 33 feet per month. From the same source we learn that the progress at the east end of the Pulpit Rock Tunnel, on the same road, was 47 feet per month, while the progress from the shafts averaged 34 feet. Saint Martin's Tunnel, completed in 1857, on the Bourbonnais Railroad in France, was worked from eight shafts, six of which were located at intermediate points on its line, and one at each entrance; the latter being adopted to expedite the work ere yet the approaches to the tunnel had been opened. The mean progress per month of each heading or gallery varied from 31½ feet at shaft No. 2, to 8½ feet at shaft No. 7, the average being but 20 feet per month.

If, therefore, 56 feet per month, or say two feet per day, the progress actually made during the last nine months of operations at the eastern end of the Hoosac Tunnel, be correctly assumed as the future rate of progress at that end, it is evident that 40 feet per month, or say 1½ feet per day, will be found the highest mean rate attainable in the working from the shaft at the west side. This joint progress of 3½ feet per day will require a period of nearly 18 years to complete the tunnel. If, however, it shall be found possible to raise the combined rate of progress to 4 feet per day, of which I can see no probability, the time will be reduced to about 15 years. But, considering the liability to interruption from accident in blasting and removing rock in the darkness, from strikes among the laborers, and the breakage of machinery, it will not be prudent to calculate on a less period than 18 years.

It may be said that hereafter the work is to be done by machinery, and thereby greatly facilitated. As this hope has existed from the earliest inception of the tunnel scheme, and still finds some adherents, I trust that a brief glance at the basis upon which it now rests will not be deemed out of place here.

The earliest notice I remember to have seen of a boring machine, is contained in the following extract, taken from the

Civil Engineer and Architect's Journal of 1847, and headed "Tunneling the Alps":—

"The Moniteur Belgé announces that experiments have been made in order to test the efficacy of a machine just invented for the purpose of effecting a new and speedy method of boring tunnels. It is proposed to apply this machine to the construction of the great tunnel about to be commenced in connection with one of the Italian lines. It was placed in front of the web, and effected a bore to the depth of seven inches in thirty-five minutes. At this rate the new invention will complete upwards of $16\frac{1}{2}$ feet of bore per day; and the proposed tunnel through Mount Cenis will be finished in the space of three years. The experiments have been repeated twice before the first engineers of France, and with the *most complete success.*"

The above and similar announcements seem to have kept alive an enthusiasm and faith on the subject in this country, until the completion and experimental trial of an improved boring machine, in presence of a legislative committee and other gentlemen, at the Hoosac Mountain in 1853. The result of this latter experiment was variously stated at the time, according to the point of view from which it was witnessed; one party claiming the machine to be a perfect success. It is matter of record in the report of the hearing before the committee, that the machine "cut into the rock $4\frac{1}{8}$ inches in 15 minutes, or at the rate of $16\frac{1}{2}$ inches per hour." And it was added that "under more favorable conditions it had cut 20 or more inches per hour." Other observers, of a mechanical turn of mind, witnessed no results tending to corroborate such reports, and on the other hand pronounced the experiments a complete demonstration of failure. Whatever may have been the facts, the machine was never afterward put in motion, and until recently, it stood a massive wreck in its old position at the east side of the mountain; the line of approach to the tunnel having been changed to get around it. Some four years later it was again announced, that "a tunneling machine which has cost $25,000 is ready to be put in operation. In some respects it is not precisely what is desired. It may and probably will require some additions or alterations, as is the case with new

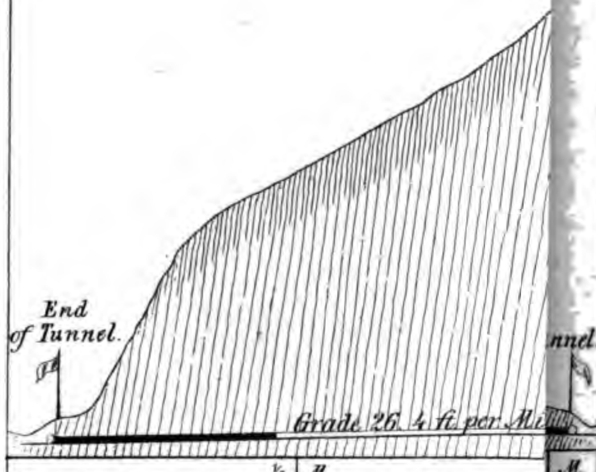
machines generally. That it will do its work, there can be scarcely the shadow of a doubt." *

The machine of 1853 had been designed to cut out, at one operation, a core of 18 feet diameter, while the later invention contemplated the boring of a gallery of the more moderate diameter of 8 feet. After the trial of the latter, in 1859, it was publicly announced "that convincing proof had been afforded to them (the contractors) that the Hoosac tunnel could and would be *perforated by machinery* within a very moderate time, although the experiment was made with a view to test the motion and cutters of the machinery, and not the probable rate of progress. The slowest rate of progress, when in motion with the slowest feed, is about fifteen inches per hour; the fast feed, about two feet per hour. Working only half the time, and with the slowest feed, the tunnel should be *perforated in* 32 *months*."** But this machine, like its predecessor of 1853, and its Mont Cenis prototype of 1847, has been abandoned and forgotten. Its place in public attention is now occupied by *experimental steam drills*, which are alleged to have been so far perfected several months ago, as to be able to penetrate the hardest granite at the rate of one inch per minute. Among mechanical engineers, however, it is a subject of grave doubt whether machines upon the new plan can be successfully used in drilling any kind of rock. In my judgment, the same features of the Hoosac rock which indicated to practical men the certain failure of the boring machines, render the successful application of any drills, driven by steam or other mechanical force, *wholly impracticable.*

It is true that machinery for drilling has been successfully introduced at Mont Cenis, and it is argued that the same thing may be done at the Hoosac mountain. It seems to me, however, that those who thus reason do not take into account the difference in the structure of the rock encountered at the two localities. "The Mont Cenis rock, on the south side, is a soft schist or slate, in horizontal beds; on the north side it is a hard schist in horizontal layers, with thin veins of quartz." The Hoosac rock is mica slate, liberally interspersed with ir-

* See printed statement by H. Haupt & Co., sent to members of Legislature in 1858–9.

** See H. Haupt & Co.'s statement, before referred to.



The Black lines at either end indicate the progress

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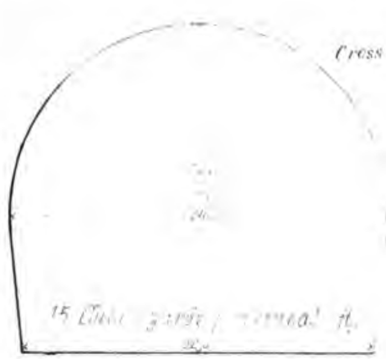
Cross Section



Tunnel as projected and estimated
upon when loan was originally granted

regular masses or nodules of quartz. This latter substance is exceedingly difficult to drill. Though in general the masses of quartz are not large, and in drilling by hand may be favored, yet, as their position cannot be foreseen, it is evident that the machine drills, working in fixed and rigid lines, must continually come in contact with them; and, with parts of the areas of drill holes in soft slate and the other parts in a flinty substance, it requires but a little mechanical knowledge to foresee such frequent breakages, as to render drilling machines worse than useless in this peculiar formation. Any rock that is solid and homogeneous, or nearly so, may be drilled by machinery, but an attempt to drill a soft rock, having flinty nodules scattered promiscuously through it, would be attended with much the same results as when, in boring soft wood, a dull augur encounters a hard knot occupying one side of its line of progress.

For the consideration of those who believe in the practicability of applying drilling machinery at the Hoosac mountain, it may be stated that the highest rate of progress yet attained, with the aid of costly machinery, at the Mont Cenis tunnel, is about 3¼ feet per day, or 85 feet per month, at each face; and the highest rate of progress anticipated for the future, is only 127 feet per month.* If this latter rate could possibly be attained at both sides of the Hoosac Mountain, the time required to go through would be about nine years.

It has also been suggested to advance the work by sinking a second shaft near the middle of the tunnel. This suggestion was considered and rejected by the company's engineer at the time of making his original estimate of cost.

The shaft was to have been located at the point A, on the accompanying profile of the mountain. (*See Plate.*) It was to be eliptical in form, with 15 and 30 feet diameters, 775 feet deep, and its cost was estimated at $132,536. Such a shaft is admitted by most engineers to be absolutely indispensable for the proper ventilation of the tunnel when completed, and the probable expense of sinking it should therefore be included in estimates of cost; but, taking into consideration the time required

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*See London Mechanic's Magazine, September 1861.

to construct it, and the progress which will be attainable in driving galleries from its base, the time and interest charges thereby saved, in completing the tunnel, would not be so great as might at first be supposed.

The sinking of the shafts of the Saint Martin's Tunnel, in France, averaging only 120 feet deep, with every facility attainable, could only be effected at the rate of about 17 feet per month. The shafts of Pulpit Rock and Black Rock Tunnels on the Reading railroad, varying from 70 to 120 feet in depth, were only sunk at the rate of 19½ feet per month. The sinking of the shaft at the western base of Hoosac Mountain is believed to have occupied some twenty-one months; if so, the rate of progress could only have been 16 feet per month. Of course the difficulties increase with the depth, and six inches per day, or 13 feet per month, is the largest mean progress that could be expected in a shaft of 775 feet in depth. This rate would require about five years for the accomplishment of the proposed central shaft.

If now we assume that after five years it will be possible to commence tunneling at the bottom of a central shaft, and thereafter to progress at the rate of 2 feet per day, while the work goes on at the other points at the rates before supposed, it will be found that the time required to complete the tunnel would be thereby reduced from 18 to 12½ years.

3rd. There remains the question,—*How much will it cost to complete and put in running order the other portions of the Troy and Greenfield Rail Road?*

The proper answer to this question depends upon which of three classes of roads be adopted as a basis of calculation.

First. For a properly located, well built, and substantial railroad between the eastern terminus and Hoosac Mountain, the entire cost of the four items of graduation, masonry, bridges and superstructure, would be not less than $30,000 per mile,—say $900,000.

Second. If it had been originally determined to construct a medium class railroad on the contractor's location, with its numerous abrupt curves and high grades, the total cost of the same four items would have amounted to about $700,000—the sum set apart by the several loan acts, to be advanced on that part of the road.

Third. To accomplish the same work on a railroad of the *character* and on the location actually adopted, I should roughly estimate the cost at $550,000 to $600,000.

I will assume that the road is to be completed upon the plan hitherto followed, with the exception that the bridges are to be in some way made capable of *holding up and safely passing trains at a moderate velocity*, and call the entire cost, of graduation, masonry, bridging and superstructure, $600,000

From an examination of the estimate made by the State engineer, on the first of July, 1861, of the quantities of all work done up to that date, and a careful inspection of the line, I conclude that the contractors have, for all purposes connected with the construction of this part of the road already expended or become obligated for, the sum of	$410,000 00
Leaving to be expended for the completion of the roadway on the 30 miles east of the mountain,	$190,000 00
Add for land damages and fencing,	42,000 00
Station buildings, turn-tables, &c.,	45,000 00
Total,	$277,000 00

With this further amount of expenditure, and for nothing less, I am of the opinion that trains might be run from Greenfield to the Hoosac Mountain. A road of the same character from the west end of the tunnel to North Adams—1 3-4 miles—would cost a further sum of $40,000, making a total of $317,000, now required for putting in running order without equipment, that part of the Troy and Greenfield Railroad between Greenfield and North Adams, exclusive of the Hoosac tunnel.

While I have, for the purposes of an estimate, assumed above that the Troy and Greenfield Railroad, when completed, is to be completed on the present location and grades, I beg not to be understood as recommending such a proceeding. Whenever built, this road should be equal in character to the Vermont and Massachusetts Railroad; for, if the Hoosac tunnel ever be completed, the Troy and Greenfield Railroad will form a link in a great and important thoroughfare. A poorly built road on a good location may subsequently be improved and perfected;

a well built road on a poor location can only be remedied by a general *re-location* and *re-construction.*

I repeat that my estimate for completing the road is based upon the existing location. This location has grades of 50 and 58 feet per mile, while the company's engineer, after a careful survey, had formerly adopted none higher than 31 feet per mile ; and in a distance of 30 miles, between the eastern terminus and the mountain, the line is lengthened one mile, and it contains 4005 degrees of curvature, of which 2806 degrees are turned upon radii, varying from 955 to 716 feet. If the line were no more crooked than the Vermont and Massachusetts Road, it would have but 1560 degrees of curvature in this distance. The Western Railroad, over its most difficult section, from a point near Westfield to the Washington summit, 30 miles, contains but 2586 degrees of curvature, the shortest radius being 1042 feet, against the 4005 degrees of curvature and shortest radius of 716 feet on a corresponding section of the Troy and Greenfield Railroad.

That this subject of allignment may be fully understood, I present a table showing the lengths, degrees, and amounts of curvature on the original and present locations, and also on a corresponding section of the Western Railroad. I have also prepared the accompanying diagram to illustrate the same subject.*

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*A copy of this diagram or map is deposited at the Senate Chamber.

Comparative Table of Alignments on the Western Railroad from Washington Summit to Westfield, 30 miles; and on the Troy and Greenfield Railroad, between Hoosac Mountain and Greenfield, by Engineer's location, 29 miles; and between same points, by Contractor's location, 30 miles.

Description of Lines.		Location of W. R. R. over its most crooked section.			Location of Troy and Greenfield R. R. by Contractors.			Location of Troy and Greenfield R. R., made by Co's Engineer.		
Kind of Curve.	Radius in feet.	Length in Miles.	No. of Curv's	Am't of Curvature.	Length in Miles.	No. of Curves.	Am't of Curvature.	Length in Miles.	No. of Curves.	Am't of Curvature.
Under 1°	5,730	1.65	4	61°				.78	4	25°
" 2°	2,865	7.08	23	485°				4.79	21	309°
" 3°	1,910	5.05	20	584°	.63	6	68°	3.80	21	424°
of 3°	1,910	1.16	6	183°	1.41	16	222°	2.71	13	429°
Betw'n 3°& 4°		1.39	4	254°						
of 4°	1,432	1.20	5	255°	3.36	34	709°	3.59	13	760°
Betw'n 4°& 5°		1.91	5	430°				.56	2	133°
of 5°	1,146	.58	3	152°	.75	8	200°	.21	1	56°
" 5½°	1,042	.60	2	182°						
" 6°	955				7.32	69	2,318°	.19	1	60°
" 7°	818				.39	3	144°			
" 8°	716				.81	6	344°			
STRAIGHT.		9.42			15.44			12.50		
		30.04	72	2586°	30.11	142	4,005°	29.13	76	2,196°
The Curvature of the Vt. and Mass. R. R. averages 52° per mile. Shortest Radius 924 feet.		Average, 86° per mile. Shortest Radius, 1,042 feet.			Average, 133° per mile. Shortest Radius, 716 feet.			Average, 75° per mile. Shortest Radius, 955 feet.		

A knowledge of the facts thus developed may suggest the expediency of a thorough field examination of the grades and allignment of the road, prior to the expenditure of any more money towards its completion. The result of such an examination by competent engineers, having in view the safe and economical operation of the road, might, and probably would be the entire abandonment of the present location. This, if found advisable, would involve a severe loss; but the two or three hundred thousand dollars, thus parted with, is a small matter, compared with the lasting disadvantages of having a section of road, badly laid out and badly constructed, in the middle of a great line of communication between Boston and the Hudson River. If this contemplated loss is to be realized, the occasion for it already exists; its magnitude can never be less, nor can it be too soon ascertained. If there be no reason to anticipate it, then a careful survey and report, before the work is resumed, will tend to allay the general distrust. Whatever of fault shall be found to exist is due primarily to the neglect of proper safeguards in the legislation of former years; and it should now be regarded as a fortunate circumstance that, before our losses have attained gigantic proportions, a fitting occasion is presented for reviewing what has been done under the imperfect arrangements of the past, and determining how far the money already loaned, has been expended in good faith by the Troy and Greenfield Railroad Company, in producing a security of any value to the Commonwealth.

Respectfully submitted,

D. L. HARRIS.

NOTE.

It has been suggested that while, in the foregoing communication, I have set down various items of expenditure on the railroad and tunnel, the probable aggregate amount expended by the present contractors, and the amount received by them, are nowhere given. I proceed to supply these deficiencies as follows :—

Estimated expenditure and liabilities incurred in working thus far the eastern division of the road from Greenfield to the Tunnel (see page 19), - -		$410,000
The Railroad Company, in their petition to the Legislature, in January, 1856, state that the gradation and masonry on that part of the road between North Adams and Williamstown are so far advanced "that a further outlay of $10,000 will prepare the same for the superstructure." This superstructure would cost some $45,000. To cover all contingencies, call the expenditures made on this section of the road, at the charge of the present contractors, -		100,000
The actual cost of the Southern Vermont section of the road did not exceed - - -		90,000
Estimated amount expended in excavating and propping up the Tunnel (see page 8), -	$141,250	
Probable cost of the approaches and shaft of ditto,	27,000—	168,250
Total, - - -		$768,250

Against these expenditures the Commonwealth has advanced scrip as follows :—

On the eastern division, - -	$505,000	
On the North Adams and Williamstown section, say one-half of the first installment paid on road and tunnel, - - -	50,000	
On the Southern Vermont section of six miles,	200,000	
On the tunnel, about - -	170,389-	$925,389
Balance, - - -		$157,139
And the towns along the line have paid - -		125,500
Making total receipts beyond the estimated cost of work done,		$282,639

It should be observed that this estimate embraces only the legitimate expenditures by the contractors towards building the railroad and tunnel. It excludes such items as the payment of interest on the State loan; interest and shave money "from twelve to twenty-four per cent." paid for temporary loans; the alleged expenditure of $25,000 in 1857 for a worthless boring machine and the subsequent cost of useless experimenting with steam drills; the alleged payment of old indebtedness of the Railroad Company, to an amount variously stated at from $30,000 to $40,000, to enable the contractors to get and retain possession of the road; and finally the payment, by contract, "into the hands of the Treasurer of the Troy and Greenfield Railroad Company, annually, the sum of not less than $500 to defray the necessary expenses of organization and printing." It *may* be that such like charges have absorbed all the surplus received from the State and from town subscriptions and left a deficiency, as claimed by the contractors, of $361,380. At all events it will be well to profit by the official hint recently given out, "that no expectations of future progress can be entertained, based upon the financial credit or pecuniary resources of the contractors of the Hoosac Tunnel."

D. L. H.

March 22, 1862.